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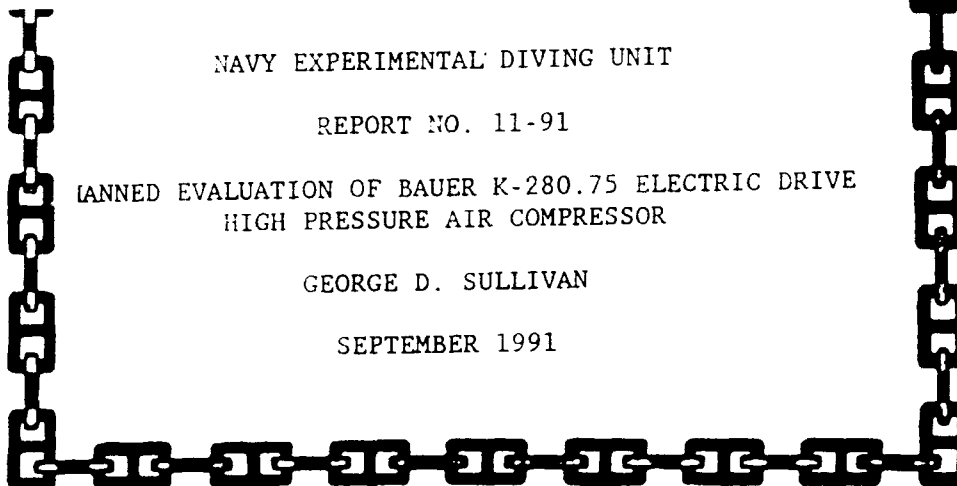
NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 11-91

ANNED EVALUATION OF BAUER K-280.75 ELECTRIC DRIVE  
HIGH PRESSURE AIR COMPRESSOR

GEORGE D. SULLIVAN

SEPTEMBER 1991



NAVY EXPERIMENTAL DIVING UNIT

91-14726



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DEPARTMENT OF THE NAVY  
NAVY EXPERIMENTAL DIVING UNIT  
PANAMA CITY, FLORIDA 32407-5001

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NAVY EXPERIMENTAL DIVING UNIT

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HIGH PRESSURE AIR COMPRESSOR

GEORGE D. SULLIVAN

SEPTEMBER 1991

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Submitted:

G.D. SULLIVAN  
GS-11  
Test Director

Reviewed:

J.W. McCARTHY  
GM-14  
Hyperbaric Engineer

B.K. MILLER, JR.  
LCDR, USN  
Senior Projects Officer

J.B. McDONELL  
LCDR, USN  
Executive Officer

Approved:

JAMES E. HALWACHS  
CDR, U.S. Navy  
Commanding Officer

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## I. INTRODUCTION

In response to NAVSEA tasking<sup>1</sup>, the BAUER electric powered K-280.75 high pressure, breathing air compressor was evaluated by NEDU to determine if the compressor would provide suitable breathing air and have a service life satisfying U.S. Navy requirements for divers air supply compressors.

For the purposes of this evaluation<sup>2</sup>, NEDU chose a method consisting of attaching an arrangement of tubing and valves from the high pressure discharge to a 42 ft floodable volume flask. The arrangement consisted of a vent valve, sample bottle fill valve, 5000 psi gauge and tubing to the flask. At startup the compressor charged the storage flasks to 2000 psig, then the vent was opened to maintain 2000+ psig while the compressor ran continuously. This method closely simulated the operation a compressor would experience in the field.

Random charge rates were taken on a daily basis while compressing from 2000 psig to 3000 psig. The compressor was operated a total of 40.5 hours.

The manufacturer shipped the compressor configured as a 3000 psi unit. After 24 hours of operation they shipped a 4th stage relief valve and temperature probe to change the compressor to a 5000 PSI unit.

## II. EQUIPMENT DESCRIPTION

The BAUER K-280.75 high pressure air compressor is driven by six V belts from a Toshiba 59 hp 1765 rpm 220/460 vac electric motor. The unit has a panel with four stage pressure gauges, one oil pressure gauge and three indicator lights for power on, high temperature and low oil pressure. The motor and compressor units are mounted on a frame set on vibration absorbers. The vibration absorbers are mounted on a skid type frame. The K-280.75 is rated to provide 100 cubic feet per minute (cfm) of free air compressed to 5000 pounds per square inch (psi). The unit is rated to operate in temperatures ranging from 41°F to 95°F. In lower temperatures a heating device is used to pre-heat the crankcase.

### A. COMPRESSOR

The compressor is a three-cylinder, four-stage, reciprocating, air-cooled unit. The cylinders are arranged in the form of an inverted T. The first and second stage cylinders are lubricated by means of a force-fed lubrication system while the other cylinder is splash lubricated. The cylinders of the compressor block, the intermediate coolers, and the after cooler are air-cooled. The compressor is equipped with two cooling fans which moves the cooling air over inter- and after- coolers and compressor cylinders.

## III. TEST PROCEDURE AND RESULTS

The compressor unit and ancillary equipment were set up in accordance with the NEDU test plan<sup>2</sup> and the K-280.75 compressor maintenance manual<sup>3</sup>. The unit was placed in an exterior work area, open to ambient temperature but

protected by an awning from direct weather. A Digitech HT series, model 5820 temperature monitor and two Yellow Springs Instruments 700 series thermistor probes were attached to measure ambient and compressor discharge temperatures.

The K-280.75 compressor maintenance manual<sup>3</sup> was used to conduct an initial receipt inspection of the equipment to ensure all parts and material were received.

#### A. ENDURANCE TEST

The compressor was operated with no load the first hour of the test. No load conditions consisted of the vent open and the back pressure valve set at 2175 psig. An air sample was taken after one hour. The compressor was operated daily with the vent adjusted to maintain the predetermined discharge pressure. During capacity evaluation the compressor was attached by flexible hose to a 42 cubic ft floodable volume flask. The capacity was verified by charging the flask from 2000 psi to 3000 psig. A total of 45.5 hours of operation were logged. The following parameters were recorded:

- |                         |                                |
|-------------------------|--------------------------------|
| (1) Date                | (10) Stage 1 Temperature       |
| (2) Time                | (11) Stage 2 Temperature       |
| (3) Total meter hours   | (12) Stage 3 Temperature       |
| (4) Total test hours    | (13) Stage 4 Temperature       |
| (5) Ambient Temperature | (14) Compressor oil level      |
| (6) Stage 1 pressure    | (15) Compressor oil pressure   |
| (7) Stage 2 pressure    | (16) Compressor discharge line |
| (8) Stage 3 pressure    | temperature                    |
| (9) Stage 4 pressure    |                                |

#### B. OIL CONSUMPTION

Prior to beginning the test, the oil sump in the compressor was measured as full on the dip stick. The compressor oil was changed 13 hours into the test (28.8 hours on the total hour meter) per the maintenance manual<sup>3</sup>. Bauer Co. supplied eight gallons of BP Energol RC-150 oil for the change. Compressor oil level was checked each morning. Oil consumption was considered negligible.

#### C. AIR SAMPLING

Air samples were taken from the compressor discharge at test hours one and 25 and sent to the NCSC Laboratory, Code 5130, for purity analysis. Results are attached as Appendix B. Both samples were within established limits<sup>4</sup>.

#### D. MAINTENANCE

Scheduled maintenance was performed at the times indicated in the maintenance manual<sup>3</sup>. Those scheduled maintenance actions performed consisted of the following:

- Checked valve function at 30 minutes after startup (daily).
- Checked oil level (daily)

- Changed oil at 25 hours on the total hour meter
- Checked automatic condensate drain (daily)

#### E. PROBLEMS ENCOUNTERED

During the original startup of the unit at NEDU, the automatic condensate drain did not activate for a period of 44 minutes. The illustrations of the timers in the manual are not the same item installed in the unit. The timers had to be set to their indicated three minute position to get them to actually actuate at the proper 15 minute intervals.

No.1 cylinder head developed an oil leak around the head gasket. After 40.5 hours approximately two teaspoons of oil had collected on the cooling fins. Oil could be seen bubbling at the gasket joint.

The high pressure air discharge line from the forth stage developed an oil leak.

Three of the six drive belts twisted and started to deteriorate, indicating a motor and compressor misalignment. There is no procedure in the maintenance manual<sup>3</sup> or aligning or checking alignment of the belts.

The pressure maintaining/non-return valve failed and begin discharging directly to atmosphere. The manual<sup>3</sup> gives only a functional description of the valve but no information to assist in attempting repairs.

The accompanying manual<sup>3</sup> provides detailed information of the K-280.75 compressor block. It does not provide detailed information concerning the accessory components on the unit.

When the ambient temperature dropped to 55°F over night, the compressor oil was chilled so the unit had to be restarted three times to pickup enough oil pressure to continue running.

#### IV. CONCLUSIONS

It is expected that equipment tested by NEDU is received in the same mechanical condition as a unit delivered to the Fleet. It should not require any repairs or alterations. The problems listed above, considered as mechanical malfunctions and breakdowns, resulted in termination of testing. This unit is not recommended for inclusion in the ANU list<sup>5</sup>.

## V. REFERENCES

1. NAVSEA Task 91-003; Testing of commercially available air compressors for divers use for ANU list.
2. NEDU Test Plan No. 91-37 Bauer K-280.75 Electric Drive High Pressure Air Compressor Evaluation
3. Bauer Maintenance Manual High Pressure Compressor Block K-280
4. U.S. Navy Diving Manual, Vol. 1, NAVSEA 0994-LP-001-9010, Air Purity Standards
5. NAVSEAINST 10560.2 (Series); Diving Equipment Authorized for Navy Use.

TEST LOG  
BAUER K-28 (MOD-1)  
ELECTRIC HP AIR COMPRESSOR EVALUATION

| 1991<br>DATE | REAL<br>TIME | TOTAL<br>METER<br>HOURS | TOTAL<br>TEST<br>HOURS | AMBI<br>TEMP | STAGE PRESSURES |               |               |               | STAGE TEMPERATURES |               |               |               | COMPRESSOR   |                 |                            |                        |
|--------------|--------------|-------------------------|------------------------|--------------|-----------------|---------------|---------------|---------------|--------------------|---------------|---------------|---------------|--------------|-----------------|----------------------------|------------------------|
|              |              |                         |                        |              | 1 ST<br>STAGE   | 2 ND<br>STAGE | 3 RD<br>STAGE | 4 TH<br>STAGE | 1 ST<br>STAGE      | 2 ND<br>STAGE | 3 RD<br>STAGE | 4 TH<br>STAGE | OIL<br>LEVEL | OIL<br>PRESSURE | DISCHG<br>LINE<br>PRESSURE | DISCHG<br>LINE<br>TEMP |
| 09-18        | 1300         | 13.0                    | 00.00                  | 84°F         | 62              | 290           | 960           | 2100          |                    |               |               |               | FULL         | 52              | 2100                       |                        |
| 09-18        | 1400         | 14.0                    | 1.0                    | 83.4°F       | 62              | 280           | 960           | 2200          | 350°F              | 338°F         | 191°F         | 203°F         | FULL         | 52              | 2200                       | 103.4°F                |
| 09-19        | 0630         | 14.0                    | 1.0                    | 72°F         | 60              | 260           | 940           | 2100          | 194°F              | 167°F         | 140°F         | 203°F         | FULL         | 50              | 2000                       | 68°F                   |
| 09-19        | 0730         | 15.0                    | 2.0                    | 76.1°F       | 61              | 265           | 940           | 2350          | 358°F              | 348°F         | 194°F         | 214°F         | FULL         | 55              | 2200                       | 102.7°F                |
| 09-19        | 0830         | 16.0                    | 3.0                    | 77.8°F       | 60              | 260           | 950           | 2750          | 320°F              | 268°F         | 194°F         | 257°F         | FULL         | 55              | 2700                       | 94.3°F                 |
| 09-19        | 0930         | 17.0                    | 4.0                    | 80.4°F       | 62              | 270           | 930           | 2700          | 285°F              | 248°F         | 216°F         | 257°F         | FULL         | 55              | 2600                       | 113.9°F                |
| 09-19        | 1030         | 18.0                    | 5.0                    | 83.6°F       | 60              | 270           | 930           | 2850          | 296°F              | 257°F         | 212°F         | 248°F         | FULL         | 55              | 2800                       | 113.9°F                |
| 09-19        | 1130         | 19.0                    | 6.0                    | 87.0°F       | 60              | 270           | 920           | 2800          | 304°F              | 238°F         | 216°F         | 257°F         | FULL         | 55              | 2700                       | 120.4°F                |
| 09-19        | 1230         | 20.0                    | 7.0                    | 93.3°F       | 60              | 270           | 920           | 2750          | 320°F              | 238°F         | 248°F         | 257°F         | FULL         | 55              | 2700                       | 126.7°F                |
| 09-19        | 1330         | 21.0                    | 8.0                    | 91.3°F       | 60              | 270           | 920           | 2750          | 328°F              | 248°F         | 248°F         | 257°F         | FULL         | 55              | 2700                       | 127.7°F                |
| 09-19        | 1400         | 21.5                    | 8.5                    | 89.4°F       | 60              | 270           | 920           | 2750          | 328°F              | 248°F         | 248°F         | 257°F         | FULL         | 55              | 2700                       | 120.4°F                |
|              |              |                         |                        |              |                 |               |               |               |                    |               |               |               |              |                 |                            |                        |
|              |              |                         |                        |              |                 |               |               |               |                    |               |               |               |              |                 |                            |                        |
|              |              |                         |                        |              |                 |               |               |               |                    |               |               |               |              |                 |                            |                        |

09-18 1400 TOOK ONE HOUR AIR SAMPLE      ADJUSTED AUTO CONDENSATE DRAIN TIMERS      CHECK COMPRESSOR OIL LEVEL

09-19 0810 TOOK CHARGE RATE      IT TOOK 20:58 TO CHARGE FROM 2000 TO 3000 PSI

**TEST LOG**

A-2

TEST LOG  
BAUER K-28 (MOD-1)  
ELECTRIC HP AIR COMPRESSOR EVALUATION

| 1991<br>DATE | REAL<br>TIME | TOTAL<br>METER<br>HOURS | TOTAL<br>TEST<br>HOURS | AMBI<br>TEMP | STAGE PRESSURES |               |               |               | STAGE TEMPERATURES |               |               |               | COMPRESSOR   |                 |                            |                        |
|--------------|--------------|-------------------------|------------------------|--------------|-----------------|---------------|---------------|---------------|--------------------|---------------|---------------|---------------|--------------|-----------------|----------------------------|------------------------|
|              |              |                         |                        |              | 1 ST<br>STAGE   | 2 ND<br>STAGE | 3 RD<br>STAGE | 4 TH<br>STAGE | 1 ST<br>STAGE      | 2 ND<br>STAGE | 3 RD<br>STAGE | 4 TH<br>STAGE | OIL<br>LEVEL | OIL<br>PRESSURE | DISCHG<br>LINE<br>PRESSURE | DISCHG<br>LINE<br>TEMP |
| 09-23        | 0630         | 28.8                    | 15.8                   | 72.6°F       | 62              | 270           | 925           | 2200          | 257°F              | 212°F         | 140°F         | 203°F         | FULL         | 52              | 2200                       | 80.9°F                 |
| 09-23        | 0730         | 29.8                    | 16.8                   | 74.8°F       | 62              | 270           | 925           | 2200          | 285°F              | 230°F         | 212°F         | 203°F         | FULL         | 54              | 2100                       | 99.8°F                 |
| 09-23        | 0830         | 30.8                    | 17.8                   | 80.0°F       | 62              | 270           | 925           | 2400          | 230°F              | 230°F         | 212°F         | 285°F         | FULL         | 54              | 2350                       | 105.6°F                |
| 09-23        | 0930         | 31.8                    | 18.8                   | 87.0°F       | 62              | 270           | 930           | 2550          | 295°F              | 230°F         | 212°F         | 248°F         | FULL         | 54              | 2500                       | 112.5°F                |
| 09-23        | 0942         | 32.0                    | 19.0                   | 89.4°F       | 62              | 270           | 930           | 2550          | 295°F              | 230°F         | 212°F         | 248°F         | FULL         | 54              | 2500                       | 114.7°F                |
|              |              |                         |                        |              |                 |               |               |               |                    |               |               |               |              |                 |                            |                        |
| 09-23        | 1030         | 32.0                    | 19.0                   | 95.2°F       | 60              | 255           | 925           | 2600          | 212°F              | 203°F         | 140°F         | 149°F         | FULL         | 50              | 2500                       | 86.9°F                 |
| 09-23        | 1130         | 33.0                    | 20.0                   | 93.8°F       | 60              | 270           | 925           | 2300          | 312°F              | 257°F         | 212°F         | 212°F         | FULL         | 54              | 2200                       | 109.9°F                |
| 09-23        | 1230         | 34.0                    | 21.0                   | 91.4°F       | 60              | 270           | 925           | 2400          | 320°F              | 257°F         | 222°F         | 212°F         | FULL         | 54              | 2300                       | 112.9°F                |
| 09-23        | 1330         | 35.0                    | 22.0                   | 92.8°F       | 60              | 270           | 925           | 2400          | 320°F              | 328°F         | 222°F         | 212°F         | FULL         | 54              | 2300                       | 114.5°F                |
| 09-23        | 1430         | 36.0                    | 23.0                   | 93.6°F       | 60              | 270           | 910           | 2000          | 306°F              | 257°F         | 212°F         | 212°F         | FULL         | 54              | 1950                       | 101.3                  |
|              |              |                         |                        |              |                 |               |               |               |                    |               |               |               |              |                 |                            |                        |
|              |              |                         |                        |              |                 |               |               |               |                    |               |               |               |              |                 |                            |                        |
|              |              |                         |                        |              |                 |               |               |               |                    |               |               |               |              |                 |                            |                        |

COMMENTS

0942 IMPROPER ADJUSTMENT OF THE VENT VALVES CAUSED THE UNIT TO CYCLE ON THE HP CUTOFF SWITCH. RESTART AT 1030 TO KEEP METER AND TEST HRS ON EVEN TIME  
1340 TOOK CHARGE RATE IT TOOK 22::17 TO CHARGE FROM 2000 TO 3000 PSIG

TEST LOG

COMMENTS



TEST LOG

1235 TOOK CHARGE RATE IT TOOK :20::34 TO CHARGE FROM 2000 PSI TO 3000 PSI COMMENT

Memorandum

18 September 1991

To: Dave Sullivan, NEDU

From: G. Deason, Code 5130

Subject: Analysis of air sample from Bauer K280 compressor  
evaluation. One hour sample.

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

| Component           | Sample   |
|---------------------|----------|
| Oxygen              | 21%      |
| Nitrogen            | 78.1%    |
| Argon               | 0.9%     |
| Carbon Dioxide      | 350 PPM  |
| Carbon Monoxide     | 1.2 PPM  |
| Total Hydrocarbons* | 2.5 PPM  |
| Total Halogens**    | <0.5 PPM |
| Methane             | 2.5 PPM  |
| Acetylene           | <0.1 PPM |
| Acetone             | <0.1 PPM |
| Freon 113           | <0.1 PPM |
| Methyl Ethyl Ketone | <0.1 PPM |
| Ethylene            | <0.1 PPM |
| Toluene             | <0.1 PPM |
| Benzene             | <0.1 PPM |
| Formaldehyde        | <0.1 PPM |
| C4+                 | <0.1 PPM |

\*Expressed as methane equivalents.

\*\*Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range of the U.S. Navy Diver's Air Purity Standards.



Glen Deason  
Chemist

Memorandum

26 September 1991

To: Dave Sullivan. NEDU

From: G. Deason. Code 5130

Subject: Analysis of Bauer K-280 compressor evaluation air sample. Twenty-five hour sample.


1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

| Component           | Sample   |
|---------------------|----------|
| Oxygen              | 21%      |
| Nitrogen            | 78.1%    |
| Argon               | 0.9%     |
| Carbon Dioxide      | 336 PPM  |
| Carbon Monoxide     | 4.3 PPM  |
| Total Hydrocarbons* | 2.6 PPM  |
| Total Halogens**    | <0.5 PPM |
| Methane             | 1.4 PPM  |
| Acetylene           | <0.1 PPM |
| Acetone             | <0.1 PPM |
| Freon 113           | <0.1 PPM |
| Methyl Ethyl Ketone | <0.1 PPM |
| Ethylene            | <0.1 PPM |
| Toluene             | <0.1 PPM |
| Benzene             | <0.1 PPM |
| Formaldehyde        | <0.1 PPM |
| C4+                 | <0.3 PPM |

\*Expressed as methane equivalents.

\*\*Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range of the U.S. Navy Diver's Air Purity Standards.

  
Glen Deason  
Chemist